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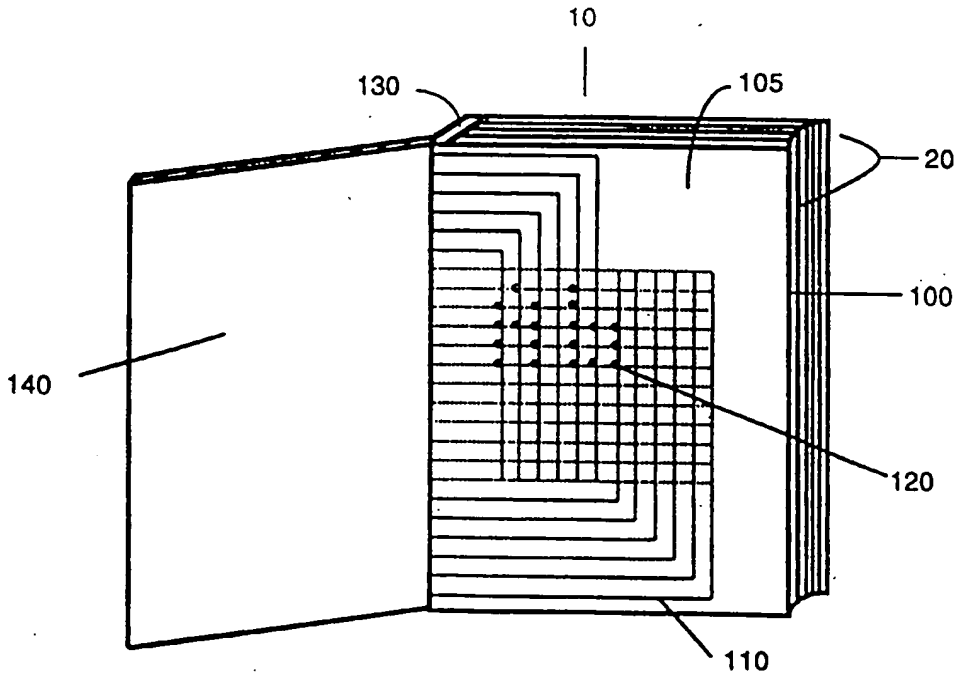

(57) Abstract

An electronic book comprising multiple, electronically addressable, page displays is described. Said page displays may be formed on flexible, thin substrates. Said book may additionnally encompass memory, power, control functions and communications.

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ELECTRONIC BOOK WITH MULTIPLE PAGE DISPLAYS

Background

Presently the concept of an electronic book (such as the omni book concept invented by Alan Kay now of Apple Computer) connotes a device with a single electronically addressable display in which pages of text are displayed sequentially in time as a function of some input. On the other hand real paper books contain multiple pages which may be accessed by means of a natural haptic input. Such pages however, once printed, are not changeable.

In this disclosure we describe an electronic book with multiple electronically addressable displays. Such an electronic book embodies the representation of information on a multiplicity of physical pages which may be may be electronically addressed or 'typeset' such that the contents of said pages may be changed by means of an electronic signal and which may further be handled, physically moved and written on. The advantages of the present invention include the ability, from within a single electronic book, to access a large realm of information, which would normally encompass many volumes of standard paper books while still maintaining the highly preferred natural haptic and visual interface of said normal paper books. As such, an electronic book with multiple electronically addressable page displays, as disclosed herein, constitutes a highly useful means of information interaction.

Summary of the Invention

The invention provides for an electronic book with multiple electronically addressable page displays. In one

embodiment such page displays may be thin, low cost and formed on paper or paper like substrates. Such substrates may be real paper, ultra thin glass, plastic, polymer, elastomer or other suitable material which embody some or a majority of paper like qualities including thinness, structure, manipulability or other characteristics normally associated with paper in its role as a hapticly and visually interactable display of information. Said page displays additionally comprise address lines and electronically addressable contrast media which may be bistable media such that texts or images written to said page displays may be maintained without the application of power. Said page displays may further comprise page strobe or page address logic for the purpose of electrically addressing a particular page in said multiple page display book.

Said book may additionally contain electronic memory, an internal power source, controls and interfaces, which may either be wired, wireless or optical, for interfacing to various sources of data or communications. Such an electronic memory may contain the informational content, both textual and graphical, comprised in a multiplicity of normal paper books. A user may then select a book of choice and cause, by means of a control, the electronically addressable pages of said book to be 'typeset' such that after some time delay the pages of said electronic book display the desired contents.

The invention provides for means of manufacturing the pages of said electronic book in a low cost way on a paper or paper like substrate. The invention further provides for means of binding such pages and addressing such a multiple page electronic book. Additional features including an interface and the ability to write in a

reversible manner and have such writing recorded are also described. Further features and aspects will become apparent from the following description and from the claims.

Brief Description of the Drawings

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

Figures 1A and B are partially perspective and partially schematic views of an electronic book with multiple electronically addressable pages.

Figure 2A is a partially perspective and partially schematic view of an electronic book with multiple electronically addressable pages open to a single such page.

Figure 2B is a partially perspective and partially schematic view of an electronic book configured with column and row address electrodes on a preceding page and a ground plane on a following page.

Figure 3 is a schematic view of an electronically addressable page configured for simplified address line layout and partial page addressability with column strobe.

Figure 4 is a schematic view of an electronically addressable page configured for multilayer address line layout and full page addressability with column strobe.

Figure 5A is a schematic view of an electronically addressable page configured for row addressing with analog selected column lines.

Figure 5B is a schematic detail of the analog column select scheme.

Figure 6A is a schematic view of an electronically addressable page configured for row addressing with digital selected column lines.

Figure 6B is a schematic detail of the digital column select scheme.

Figure 6C is a schematic view of an electronically addressable page configured for digitally selected row lines and column lines.

Figure 6D is a schematic detail of an array of row and column addressing lines suitable for in-plane switched or dielectrophoretic switched electronically addressable contrast media.

Figures 7A-7D are schematic details of various electronically addressable contrast media.

Figures 7E-7F are schematic details of a two part dye based electronically addressable contrast media

Figures 7G-7L are schematic details of in plane switched and near in-plane switched electronically addressable contrast media.

Figures 7M-P are schematic details of dielectrophoretic switched electronically addressable contrast media.

Figures 8A-8E are schematic details of various switch and relay assemblies.

Figures 9A-9E are schematic details of various switch structures.

Figures 9F-9I are schematic details of various printed switch structures.

Figures 10A-D are schematic details of various optically addressed and optoelectronic switch structures.

Figures 11A and B are partially perspective and partially schematic views of a single page of an electronic book and a means for binding a multiplicity of such pages.

Figure 12 is a schematic view of an electronic address/date book with multiple display pages.

Detailed Description of a Preferred Embodiment

Referring to Figure 1, a book 10 is composed of multiple electronically addressable page displays forming a multiple page display ensemble 20 in which each page of said ensemble may be individually electronically addressed. Said book may additionally contain: An internal power source 40 such as a battery; Electronic display drivers 50 to write information to said page displays where said drivers may write information contained in a memory or alternatively may write information obtained via a suitable interface or alternatively may write information from another source such as an electronic pen or stylus or from another suitable source.; Memory 60 which may be a solid state memory such as flash memory or bubble memory or may be another form of memory such an optical disk or magnetic media or may be any other form of memory. Such memory may contain information including text and/or graphics. Such information may be for instance the text and graphics of a selection of books or journals. Further said memory may be programmable or reprogrammable. Alternatively said memory may be permanent. Said memory may also be removable for the purposes of reprogramming or for other purposes. Alternatively said memory may be a fixed

memory. Said memory may also be interfaced to said electronic drivers and may further be interfaced to an external source.; A fast display 70 which may be an LCD display for displaying a certain subset of the information contained in said memory such as book titles.; Control buttons 80 which may be used for accessing the information contained in said memory and causing said information to be displayed on said fast display or on said page displays or to access some other control function.; A title space 30 which may be composed of a similar electronically addressable structure to said page displays.; Additional electronic elements 90 which may include a receiver or transmitter or other means of communications such as a data port or a modem or any other suitable interface. Said additional components may additionally contain a processor or microprocessor and any other components known in the art of computers or portable computers or any other electronic components useful in the operation of said electronic book.

Referring to Figure 2A said book 10 contains electronically addressable page displays 100 which combine to form an ensemble of multiple page displays 20. Said book may additionally comprise a cover 140 and spine 130 which may hold various elements as described in reference to Figure 1. Such page displays 100 are composed of a substrate 105, an electronically addressable contrast media 120, and address lines 110. Said book 10 and said page displays 100 are configured such that substantially different information can be written or electronically 'typeset' on the different page displays 100 which comprise the multiple page ensemble 20.

In a preferred embodiment said page displays may be thin, low cost and formed on paper or paper like

substrates. Such substrates may be real paper, synthetic paper, ultra thin glass, plastic, polymer, elastomer, thin metal, carbon fiber or other suitable material which embody some or a majority of paper like qualities including thinness, structure, manipulability or other characteristics normally associated with paper in its role as a hapticly and visually interactable display of information.

Said address lines may be composed of transparent conducting polymers, transparent conductors such as Indium Tin Oxide, thin metal conductors or other suitable conductors. Such address lines may be applied by vacuum deposition, sputtering, photolithography or may be printed via ink jet systems or laser printer systems or may be applied via other appropriate means. Further such address lines may additionally be insulated with an appropriate insulator such as a non conducting polymer or other suitable insulator. Alternatively insulating layers may be applied in such manner to effect electrical isolation between row and row conducting lines, between row and column address lines, between column and column address lines or for other purposes of electrical isolation.

Said contrast media may be electrochromic material, rotatable microencapsulated microspheres, polymer dispersed liquid crystals (PDLCs), polymer stabilized liquid crystals, surface stabilized liquid crystal, smectic liquid crystal, ferroelectric material, electroluminescent material or any other of a very large number of contrast media known in the prior art. Certain such contrast media, such as microencapsulated media may be printed via an ink jet or ink jet like system or may be applied via other appropriate means.

Figure 2B is an electronic book configured with row 230 and column 210 electrodes on the back of a preceding page 107 and a ground plane 108 embedded in a following page 100. Such an arrangement allows for addressing of said electronic page displays when said electronic book is in addressing of said electronic page displays when said electronic book is in the closed state while allowing said page displays to be viewed without having to look through a top a electrode when said book is in the open condition. The operation of such addressing is effected by either cancelling or adding to the electric field produced by address lines of the complimentary orthogonality.

Figure 3 depicts a preferred embodiment of a page display 100 incorporating a simplified address line scheme configured for partial page addressability. A substrate 105 has deposited on or embedded in it an underlying array of row address lines 230, an electronically addressable contrast media 120 and an array of column address lines 210. A book configuration requires that all address lines are substantially accessible along or near a single edge of the book page. Such is the case with the schemes described in this disclosure. In the preferred embodiment row lines 230 and column lines 210 are common to each page in the multiple page ensemble. Pages are addressed individually via a page address strobe comprised of page address strobe control lines 200 and 205 and page address strobe switches 220 which control whether or not a particular page's column address lines are active in response to signal applied to said page address strobe control lines. It is understood however that in each of the embodiments described page strobing may be obviated in exchange for a more complicated spine driver in which each page in the multiple page ensemble may be wired directly

and separately to the display driver.

Figure 4 depicts a preferred embodiment of a page display 100 incorporating a multilayer address line scheme configured for full page addressability. Edge column address line connectors 240 are connected to column address lines 250 via a conducting connection 260. Such a connection may be of conducting polymer, ITO, metal or other suitable conductor or may be a direct connection of the line 240 to 250 which may further be bonded with a laser weld or non conducting or conducting epoxy or other adhesive. In all other areas where column address line connectors 240 cross column address lines 250 there is no conducting connection as effected by the placement of a suitable insulating layer. The page strobe composed of page strobe control lines 200 and 205 and page strobe switches 220 operate as in Figure 3 to control the state of said column address lines. As before column and row address lines may be common to each page in the multiple page ensemble.

Figures 5A-B are schematic views of an electronically addressable page 100 in which row lines 260 emanate from the page edge and are connected to the display driver. Row lines may be common to each page. Column address lines are analog selected by means of applying appropriate voltages between analog column switch control line 290 and 300 and 310 and 320.

Referring to the detail, the analog column select scheme operates as follows: Each column address line 270 may be denoted by a number j between 1 and N where N is the total number of column address lines per page. Each column address line in turn is controlled via a set of two column switches, 330 and 340, each of which in turn may be given designations k and l for the top and bottom control

switches (330 and 340) respectively where k and l both range from 1 to N.

Said column switches 330 and 340 have a uniform threshold in which the column address lines 270 which they control become active (closed circuit, denoted by a black filled box) if said column switch's control lines 290 and 300 and 310 and 320 respectively have a potential difference greater than a threshold voltage V_{th} as measured at said switch control line input. Resistors 350 connect said switches 330 or 340 such that for a given applied potential difference on said switch control lines each switch sees a different and monotonicly scaled potential difference at its control line input face. Consider the case in which switch control line 290 and 310 are held at voltage V_1 and V_2 respectively and switch control lines 300 and 320 are held at ground. The criterion for column address line j to be active and thus be at the potential V_c applied to common column address line bias 280 is:

$$V_1/(j*R) > V_{th} \text{ and } V_2/((N-j)*R) > V_{th}$$

Thus by choosing an appropriate value of V_1 and V_2 a single column address line may be selected. In the example shown in the detail black filled control switches denote a closed switch condition and white filled control switches denote an open switch condition. Column line 2 has been made active by the appropriate choice of V_1 and V_2 whereas all other column lines are inactive as for all other column lines at least one column control switch is in the open circuit state. It is understood that a further simplification may be made by making V_2 = constant - V_1 such that only a single voltage line need be

addressed. The analog column switch control line or lines are unique and not common to each page thereby allowing for page selectability.

Figures 6A-B are schematic views of an electronically addressable page 100 in which row lines 260 emanate from the page edge and are connected to the display driver. Row lines may be common to each page. Column address lines are digital selected by means of applying appropriate logical values for digital column switch control lines 380,382 and 384 with ground 390.

Referring to the detail, the digital column select scheme operates as follows: Rows of digital column switches 370,372 and 374 control column address lines such that all such said column switches in a given column must be in a closed circuit state (black filled box) for said column address line to be active. In order to control N column address lines it is required to have S rows of column switches such that S is the least integer greater than Log[N]/Log[2]. In the example shown in the detail 3 rows of such column switches 370,372 and 374 control 8 column address lines 270. The first such row is wired such that a logical 1 applied to the said row's column switch control line, 380, yields a state in which the first N/2 switches are in a closed circuit state and the second N/2 switches are in an open circuit state. The second row, 382, is wired such that said switch states alternate with a period of $N*2^{-2}$. The m^{th} row alternates with a period of $N*2^{-m}$. Such a configuration allows for the unique selection of a single column address line such that said selected column address line becomes active with the potential applied to common column address bias 395. In the example shown in the detail column address line 3 becomes active upon application of the logical values 1,

0, 1 to column switch control lines 380, 382 and 384 respectively.

Referring to Figure 6C an electronically addressable page 100 may be constructed in which both column address lines and row address lines are digitally selected. Such a scheme minimizes the total number of address lines emanating from the page and may simplify connections to off board address logic. Such a scheme employs digital column switches 371, digital column switch control lines 381 with ground 390 and column address line common terminal 395 as in Figure 6A-B as well as digital row switches 373, digital row switch control lines 383 with ground 391 and row address line common terminal 396. In this implementation the total number of leads required to emanate from the display page for the purpose of addressing are Log[Nc]/Log[2] + Log[Nr]/Log [2] + 4 in which Nc are the number of column address lines and Nr are the number of row address lines. The additional 4 provides for switch grounds and common terminal lines. It is recognized that an even smaller number of emanating leads may be employed by further addressing said switch control lines with a further bank of control switches.

Finally it is also understood that any other suitable digital scheme in which each page has a page address may be employed as is known in the literature and prior art of display addressing.

Referring to Figure 6D row electrodes 260 and column electrodes 270 may be configured to perform an in-plane switching function by means of insulating said lines from each other by the addition of an insulating pad 264 and by addition of an added address line section 262. Two such in-plane switching arrays, one lying on top of the other are suitable for performing a dielectrophoretic switching

function.

Referring to Figures 7A-D a great many electronically addressable contrast media are known in the literature and prior art. In one embodiment a dielectric sphere 440 with substantially different contrast hemispheres may be microencapsulated in a microcapsule 420 and may be free to rotate in a fluid 430. The orientation of such a sphere may be controlled via the applied potential difference between electrode or address line 400 and 410. If one or both such electrodes are substantially transparent then an electronically addressable contrast may be effected. Such systems are known to posses inherent bistability or memory during open circuit due to electrostatic stiction.

In another system polymer dispersed liquid crystals (PDLCs) 450 may be microencapsulated or encapsulated in a microcapsule or capsule 420. In the absence of an applied bias between electrodes 400 and 410 said PDLCs are not oriented and are thus highly scattering and thus opaque. Under the application of a bias said PDLCs become aligned and are thus substantially transmitting. Thus, again, an electronically addressable contrast may be effected. Additionally such a contrast system may be a polymer stabilized system as is known in the prior art such that said system exhibits bistability.

In another system oriented LCD molecules 470 which may be microencapsulated in microcapsule 420 may be caused to rotationally orient and thus change the polarization of incident light upon application of a bias between 400 and 410. When viewed through a polarizer 460 said arrangement may again effect an electronically addressable contrast media.

In another system an electrochromic material 480 and an electrolyte 490 which may be a solid electrolyte are

sandwiched between electrodes 400 and 410. Application of a potential difference between said electrodes effects an electronically addressable change of contrast. Said electrochromic systems are known in the prior art to be capable of memory, threshold, color capabilities and operability with a solid electrolyte system.

Referring to Figures 7E-F, another system, to be described in the provisional patent application by Joseph M. Jacobson filed on even date herewith and incorporated herein by reference, a dye material 491 which may have an associated positive charge or may be bound to a particle with a positive charge may be brought into proximity or separated from the pH altering or solvent substance 492 which may have a negative charge or be bound to a particle with a negative charge by means of an electric field applied to electrodes 400 and 410. Such a chemical system, which may encapsulated in capsule 420, may constitute a field effect electronically addressable contrast media in such case as the color of said dye material is altered by said pH altering or solvent substance.

Referring to Figures 7G-L, it may be desirable to avoid the use of a top transparent electrode 400 as such electrodes may degrade the optical characteristics of the display. This may be accomplished in a reflective display by employing in-plane switching. In plane switching techniques have been employed in transmissive LCD displays for another purpose, namely to increase viewing angle of such displays. In the provisional patent application by Joseph M. Jacobson filed on even date herewith, several in plane switching techniques may be employed to obviate the need for a top electrode. In one such system a dye material with an associated positive charge 491 and a pH

or solvent substance with an associated negative charge 492 may be separated by means of an in plane electric field effected by means of application of a potential to in plane electrodes 495 and 496. Such a system is viewed from above and thus said electrodes may be opaque and do not effect the optical characteristics of said display.

In another such system a bistable liquid crystal system of the type demonstrated by Minolta is modified to be effected by in plane electrodes such that a liquid crystal mixture transforms from a first transparent planar structure 497 to a second scattering focal conic structure 498.

In another scheme, suitable for two color microspheres, a near in-plane switching arrangement may be realized in which a two color microsphere 440 is encapsulated in an outer capsule 420 which sit in a hole created by a middle electrode 498. Applying a bias between said middle electrode 498 and a bottom electrode 497 causes said sphere to rotate as a function of the polarity of said bias.

In another scheme a field effect electrochromic contrast media may be realized by means of a microcapsule 420 containing phosphor particles 500 and photoconductive semiconductor particles and dye indicator particles 501 in a suitable binder 499. Applying an AC field to electrodes 495 and 496 causes AC electroluminescence which causes free charge to be generated in the semiconducting material further causing said dye indicator to change color state.

Referring to Figures 7M-7P an entirely different means may be employed to effect a rear address of said contrast media. In these schemes, disclosed in the provisional patent application by Joseph M..Jacobson filed on even date herewith, the dielectrophoretic effect is

employed in which a species of higher dielectric constant may be caused to move to a region of high electric field.

Referring to Figures 7M and 7N a non-colored dye solvent complex, 503, which is stable when no field is applied across electrode pair 502 may be cause to dissociate into colored dye 504 and solvent 505 components by means of an electric field 506 effected by a potential on electrode pair 502.

In another system stacked electrode pairs 502 and 507 may be employed to effect a high field region in a higher 506, or lower, 508 plane thus causing a higher dielectric constant material such as one hemisphere of a bichromal microsphere, 440 or one species 483 of a mixture of colored species, 483 and 484 to migrate to a higher or lower plane, respectively, and give the effect of differing color states. In such schemes materials 509 which may be dielectric materials or may be conducting materials may be employed to shape said electric fields.

It is understood that any other electronically addressable contrast media may readily be substituted for those described above.

Referring to Figures 8A-E means are described for implementing address line control switches. Referring to the left uppermost figure address input line 510 is separated from address output line 520 by means of space 570 which may contain a polarizable fluid, conducting beads or filings or other such substance such that when a bias is applied between switch control lines 530 and 540 setting up an electrostatic field through insulators 550 and 560 and space 570 such that a substantial decrease in resistivity is effected between lines 510 and 520.

In another system address input line 510 is separated from address output line 520 by means of space 600 which

may contain magnetically poled microspheres 610 which have a substantially conducting hemisphere and a substantially insulating hemisphere. Application of a current to loop control line 580 effects a magnetic field as depicted which causes said microspheres to line up with said substantially conducting hemisphere oriented such that they bridge said gap or space 600 thus effecting a substantially closed circuit between 510 and 520.. Insulator 590 insulates said switch control lines from said address lines.

In another system address input line 510 is separated from address output line 520 by means of space 630 which contains magnetically poled and electrically conducting spheres 640. Application of a current to switch control line 620 effects the generation of a magnetic field as depicted causing said spheres to line up forming a conducting bridge between 510 and 520 as is known in the literature and thus effecting a substantially closed circuit between 510 and 520.

In another system address input line 510 has integral to it a conducting cantilever 515 separated from address output lines 520 by means of a gap. Application of a potential difference between line 510 and switch control line 650 causes an electrostatic attraction between said cantilever and said address output line thus effecting a substantially closed circuit between 510 and 520. Insulator 660 insulates said switch control line from said address output line.

In another system address input line 510 has integral to it a conducting cantilever which further has integral to it a magnetic substance 690. Said magnetically active conducting cantilever is separated from address output lines 520 by means of a gap. Application of a current to

switch control loop 670 effects the generation of a magnetic field which causes said conducting cantilever to bend and make contact with said address output line thus effecting a substantially closed circuit between 510 and 520. Insulator 680 insulates said switch control line from said address output line.

Referring to Figures 9A-E several schemes are known in the literature and the prior art for effecting an electronic switch or transistor function without moving parts. Referring to the upper figure address input line 510 is electrically isolated from address output line 520. Layers of scandium diphthalocyanine ($ScPc_2$) 740, Nickel Pthalocyanine (NiPc) 730, Silicon Dioxide (SiO_2) 720 and n doped silicon (n-Si) bridge said address lines. By incorporating a control gate 700 a field-effect transistor in this case employing a dipthalocyanine thin film may be realized as is known in the literature. Such a structure may act as an address control line switch as said gate 700 may substantially control the flow of current from said address input line 510 to said address output line 520.

In another arrangement address input line 510 is isolated from address output line 520 by means of a stack including semiconducting polymer layers 750 and a switch control line 760 consisting of a camphor sulfonic acid protonated polyaniline (PANI-CSA) grid electrode filled with a semiconducting polymer. Such a structure may act as an address control line switch as such structure as just described forms a polymer grid triode (PGT) as is known in the literature such that said switch control line 760 may substantially control the flow of current from said address input line 510 to said address output line 520. Switch control line 760 may alternatively consist of a metal film in which case the described structure forms a

current switch.

In another scheme a bipolar spin switch is formed by means of paramagnetic metal film 850 and ferromagnetic films 870 and 880. A bias applied between nonmagnetic metal electrode 860 and ferromagnetic film 870 serves to regulate the current between input electrode 510 and output electrode 520 thus forming a switch as is known in the existing literature.

In another scheme a hall effect switch may be effected whereby a potential may be formed across a hall effect material 910 between input electrode 510 and output electrode 520 by means of applying simultaneously an incident current injected by means of electrode 890 and collected by means of electrode 900 and a magnetic field H, perpendicular to said current, created by means of application of current to loop control line 670 and insulated by insulator 680.

In another scheme, curved resistor 930 which is electrically but not thermally insulated by means of insulator 940 may be caused to be heated by means of application of a current to said resistor causing the impedance in thermistive material 920, which posses a negative temperature coefficient of resistance, to drop thus lowering the impedance between input electrode 510 and output electrode 520.

Some of the above described devices such as those formed of conducting polymers have considerable utility in the present application as they posses the property of structural flexibility, tunable electronic properties and simplified deposition procedures (such as spin casting) which may be suitable for certain substrates such as real paper or paper like substrates. It is understood however that standard inorganic semiconductor technology such a Si

or GaAs may be employed especially if suitable substrates such as ultra thin glass were employed for part or all of the page display.

Referring to Figures 9F-I in addition to standard semiconductor technology which involves deposition and subsequent etching it may be useful, especially on atypical substrates, to deposit a semiconductor ink from which transistors and switches may be fabricated. As described in the provisional patent application by Joseph M. Jacobson filed on even date herewith, a semiconductor ink 943 may be fabricated by dispersing a semiconductor powder 945 in a suitable binder 946. Said semiconductive powder may be Si, Germanium of GaAs or other suitable semiconductor and may further be doped, prior to being made into a powder, with n-type impurities such as phosphorous, antimony or arsenic or p-type impurities such as boron, gallium, indium or aluminum or other suitable n or p type dopants as is known in the art of semiconductor fabrication. Said binder 946 may be a vinyl, plastic heat curable or UV curable material or other suitable binder as is known in the art of conducting inks. Such an binder 946 when cured brings into proximity said semiconductive powder particles 945 to create a continuous percolated structure with semiconductive properties. Said semiconductive ink 943 may be applied by printing techniques to form switch or logic structures. As indicated in Figures 9F-I an NPN junction transistor may be fabricated consisting of a n-type emitter 950, a p-type base 954 and a n-type collector 952.

Alternatively a field effect transistor may be printed such as a metal oxide semiconductor. Such a transistor consists of a p-type material metal oxide semiconductor. Such a transistor consists of a p-type

material 970, an n-type material 966 an n-type inversion layer 968 an oxide layer 962 which acts as the gate a source lead 960 and a drain lead 964.

Referring to Figures 10A-D means are described for implementing control switches based on optical control or optoelectronic devices. Referring to the left uppermost figure electroluminescent material 780 is sandwiched between exciting electrodes 770 and 790 forming an electroluminescent light emitting structure which is electrically isolated by means of transparent isolator 795. Emitted light from said electroluminescent light emitting structure causes photoconductor 760 to undergo a decrease in impedance thus lowering the effective impedance between input electrode 510 and output electrode 520 as is known in the literature. Layer 800 is an opaque layer which serves to optically shield other components from said light emitting structure.

Alternatively a switch may be constructed where said electroluminescent light emitting structure is replaced by an optical fiber 802 which may be modified to scatter light to said photoconductor 760 and optical fiber light source 804 which may be a light emitting diode or laser diode or other suitable light source.

In another arrangement, said photoconductor may be replaced by a photodiode composed of an output electrode 510 with aperture 805, a heavily doped p+ layer 810 , a depletion layer 820, a lightly doped n-type layer 830, an n+ layer 840 and an input electrode 520. Alternatively it is understood that any other photodiode or phototransistor structure as is known in the prior art may be employed.

Figures 11A and B depict a preferred construction of a single electronically addressable page 100 and the means by which a multiplicity of said pages may be bound to form

an ensemble of multiple page displays 20. Referring to the schematic of the single page, primary page substrate 105 may additionally encompass a second substrate part 150 which may be of a different material than said primary substrate such as a plastic or glass material with substantially different mechanical or electronic properties than the primary substrate material. Said second substrate material may have situated upon it page strobe or address logic 165 and page strobe or page address control lines 175. Said second substrate may further encompass apertures 160.

Referring to the perspective view of a multiplicity of pages such single page displays 100 may be combined to form a page display ensemble 20. Row or column address lines 110 may be connected to said apertures 160 such that display driver lines 185 may connect said address lines of each page 100 in said page ensemble thus forming common address lines from page to page. Such display driver lines may then further be connected to display driver 180. Such display driver lines which are common to each display page and which further connect through said apertures of said display pages may further serve to mechanically bind said pages to form said page display ensemble. Page strobe or page address lines 175 which are not common to each page may be connected to page strobe or page address driver 170.

Alternatively said substrate 105 may be of a single material. In another configuration said apertures 160 may be obviated and said control lines may be extended to the page edge where they may be connected to said driver lines. In another configuration additional mechanical bindings may be employed to mechanically bind said pages. It is readily understood that additional or alternative

techniques of mechanical binding as is known in the art of book manufacture and other means of electrical connection as is known in the art of electronics and display manufacture may be employed.

Referring to Figure 12 the materials and configurations of the previous descriptives may be employed to construct an electronic address book/date book 980 with multiple electronically addressable display pages, 988, said book may have driver electronics, 986 and an interface 984 to another computer of computer network. Said interface 984 may be wired or wireless or optical. Finally said address book/date book may be permanently printed information 983 as well as changeable information 982.

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

CLAIMS

What is claimed is:

1. An electronic book comprising multiple electronically addressable page displays in which each page display comprises a substrate, address lines and electronically addressable contrast media and in which means are provided for individually addressing said page displays which form in their composite a page display ensemble.

2. The book of claim 1 in which said address lines and said contrast media are situated on to said substrate such that both sides of said page displays may be independently addressed.

3. The book of claim 1 in which said page displays are formed on real paper or paper like substrates.

4. The book of claim 1 in which said page displays are formed on thin single layer substrates.

5. The book of claim 1 in which said page displays substrates are composed of natural paper, synthetic paper, ultra thin glass, plastic, polymer or elastomer.

6. The book of claim 1 in which said contrast media of said page displays is in encapsulated or microencapsulated form.

7. The book of claim 1 in which said contrast media consists of electrochromic material, rotatable microencapsulated microspheres, rotatable microencapsulated microcylinders, liquid crystal material, polymer dispersed liquid crystal material, polymer stabilized liquid crystal material, surface stabilized liquid crystal material, smectic liquid crystal material, ferroelectric material or electroluminescent material.

8. The book of claim 1 in which said address lines consist of conducting polymers, indium tin oxide or thin metallic conductors.

9. The book of claim 1 in which said address lines or said contrast media or both are of such composition that they may be applied to an arbitrary substrate surface.

10. The book of claim 1 in which said address lines or said contrast media or both are applied by means of vacuum deposition, sputtering, photolithography electroplating, screenprinting, automated fluid dispensing metal salt reduction, or printed via ink jet systems or laser printer systems.

11. The book of claim 1 in which said contrast media consists of a multiplicity of subsets of contrast media such that said subsets display substantially different colors in response to said electronic addressing.

12. The book of claim 1 in which said page displays are configured such that said address lines emanate from or near a single edge.

13. The book of claim 1 in which row lines or column lines or both are common to each page display in the page display ensemble.

14. The book of claim 1 in which said page displays are configured such that all columns lines or all row lines or both on individual pages may be controlled via a page strobe.

15. The book of claim 14 in which said page strobe consists of switches which further comprise moving elements or contacts.

16. The book of claim 14 in which said page strobe comprises switches which further consist of solid state elements.

17. The book of claim 14 in which said page strobe comprises switches which further consist of optically controlled or optoelectronic elements.

18. The book of claim 14 in which said page strobe comprises switches which further consist of an orientable or polarizable fluid.

19. The book of claim 14 in which logic elements are formed by means of a printed process.

20. The book of claim 1 in which row lines or column lines or both are analog selected.

21. The book of claim 20 in which logic elements are formed by means of a printed process.

22. The book of claim 20 in which said analog selecting comprises switches which further consist of moving elements or contacts.

23. The book of claim 20 in which said analog selecting comprises switches which further consist of solid state elements.

24. The book of claim 20 in which said analog selecting comprises switches which further consist of optically controlled or optoelectronic elements.

25. The book of claim 20 in which said analog selecting comprises switches which further consist of an orientable or polarizable fluid.

26. The book of claim 1 in which row lines or column lines or both are digital selected.

27. The book of claim 26 in which said digital selecting comprises switches which further consist of moving elements or contacts.

28. The book of claim 26 in which said digital selecting comprises switches which further consist of solid state elements.

29. The book of claim 26 in which said digital selecting comprises switches which further consist of optically controlled or optoelectronic elements.

30. The book of claim 26 in which said digital selecting comprises switches which further consist of an orientable or polarizable fluid.

31. The book of claim 26 in which logic elements are formed by means of a printed process.

32. The book of claim 1 in which individual page displays in the page display ensemble have a unique digital or analog page address.

33. The book of claim 1 in which said page display substrates are comprised of a multiplicity of substrate materials.

34. The book of claim 33 in which page strobe or page address logic is resident on a substantially different substrate material than that of said contrast media.

35. The book of claim 1 in which said page display substrates have integral to them a set of apertures.

36. The book of claim 1 comprising additionally any of the following: memory, an internal power source, controls and interfaces, which may either be wired, wireless or optical, for interfacing to various sources of data or communications.

37. The book of claim 1 in which said page display ensemble is comprised of a stack of flexible pages, each having an electronically controlled display; and

further comprising memory having stored therein data representing text or graphics or both to be displayed on the page displays; and

an electronic display driver which controls display of the text or graphics or both from memory on the flexible page displays.

38. The book of claim 1 in which provision are provided for entering hand written notes on said page displays via an appropriate digitizer which is not integral to said page display and using data acquired by said digitizer to cause appropriate marks to be displayed via electronic addressing on said page display.

39. The book of claim 1 in which provisions are provided for entering hand written notes on said page displays via an appropriate digitizer which is integral to said page display and using data acquired by said digitizer to cause appropriate marks to be displayed via electronic addressing on said page display.

40. The book of claim 38 in which said digitizer data may be stored in a memory for later retrieval.

41. The book of claim 39 in which said digitizer data may be stored in a memory for later retrieval.

42. The book of claim 1 in which said electronically addressable contrast media is addressed by means of in-plane switching or near in-plane switching such

that said display pages may be operated in the absence of a top electrode.

43. The book of claim 1 in which said electronically addressable contrast media is operated on the principle of a dielectrophoretic effect.

44. The book of claim 43 in which said dielectrophoretic contrast media is operated by means of rear electrodes such that said display may be operated in the absence of a top electrode.

45. The book of claim 1 in which said electronically addressable contrast media comprises electrophoretic material, bistable liquid crystal material, guest host liquid crystal material, multipart color changeable dye system material, multipart color changeable dye system in electrorheological fluid, magnetophoretic material, electroluminescent material or electroluminescent material in conjunction with a changeable dye system.

46. The book of claim 1 in which said electronically addressable contrast media is microencapsulated.

47. The book of claim 1 in which address lines on the back of a preceding page are employed to address the following page such that both column and row address lines are together on said preceding page or are together on said following page and a ground plane exists on the other page.

48. The book of claim 1 in which one or more sets of row address lines and column address lines are configured such that said lines are separated by an insulating pad and such that one or more of said lines has associated with it an added address line section.

49. The book of claim 1 in which one or more row address lines or column address lines have associated with them conducting or dielectric materials which serve to shape the electric field effected by said line.

50. The book of claim 1 configured to be an address, date or memo book which additionally includes any of the following: memory, battery, drive logic, interface which may be wired, wireless or optical and/or stylus input and which may have both electronically changeable portions and permanently printed portions.

51. An electronic book comprising:

a stack of flexible pages, each having an electronically controlled display;

memory having stored therein data representing text to be displayed on the page displays; and

an electronic display driver which controls display of the text from memory on the flexible page displays.

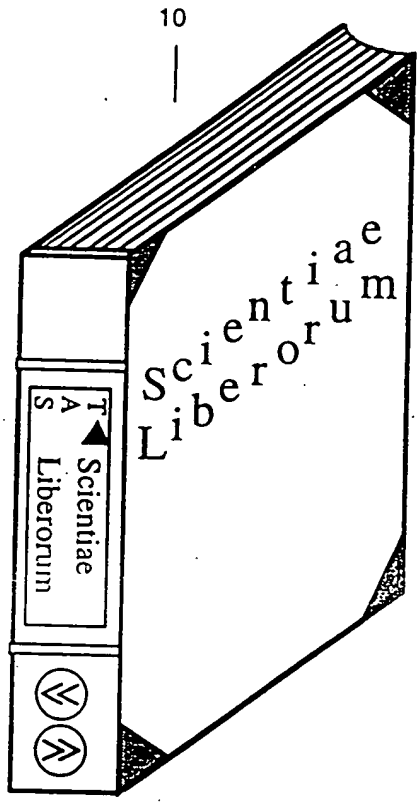
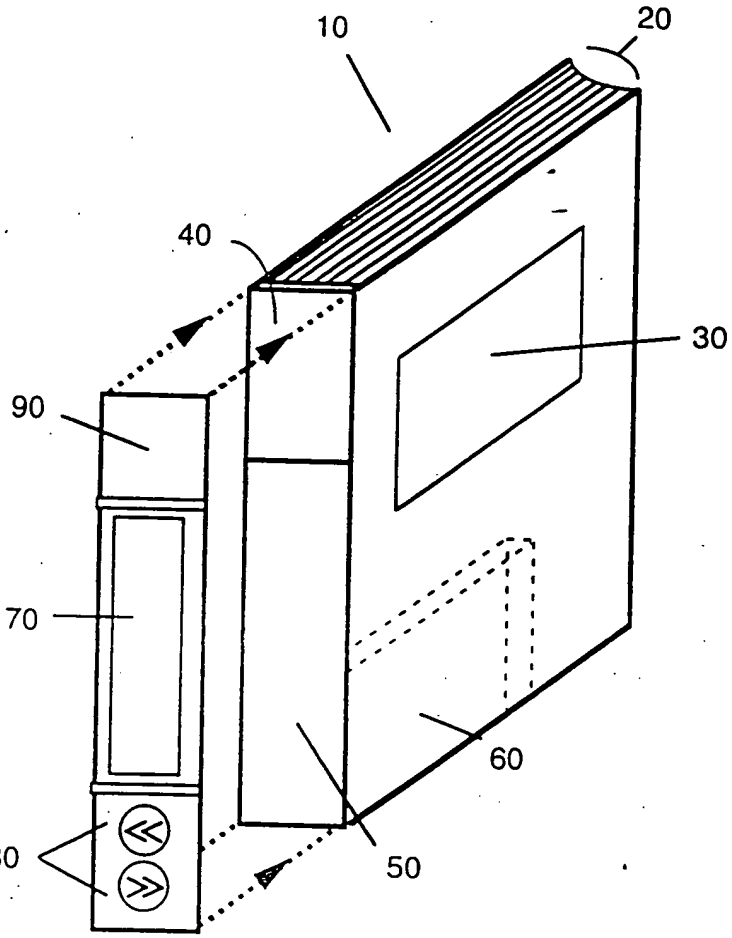

10
Scientiae
Liberorum
TAS
Scientiae
Liberorum

FIG. 1A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20
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70
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80
50

FIG. 1B

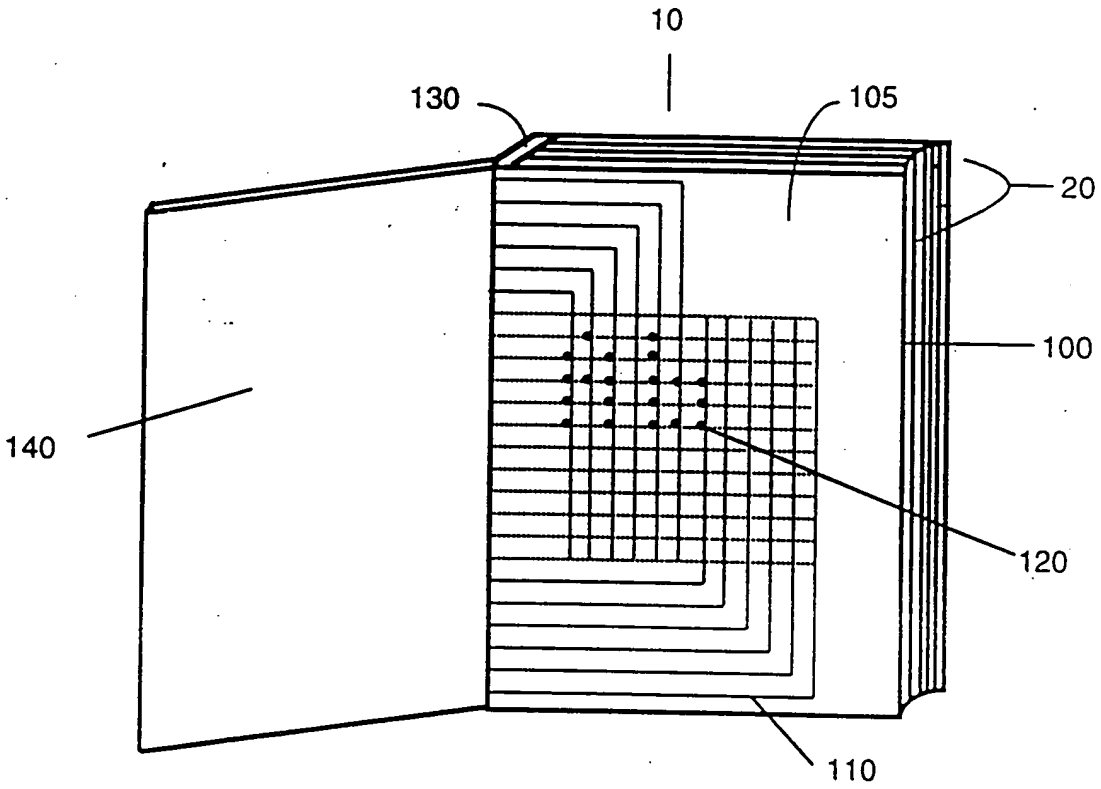


FIG. 2A

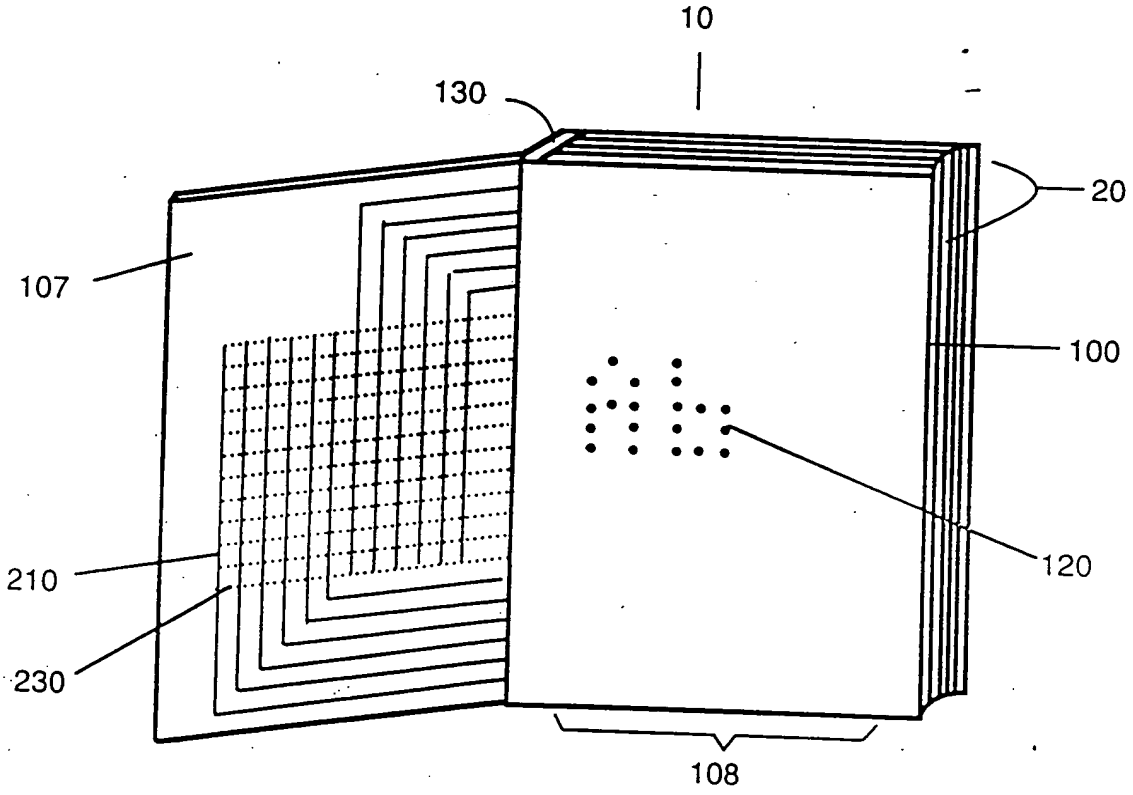


FIG. 2B

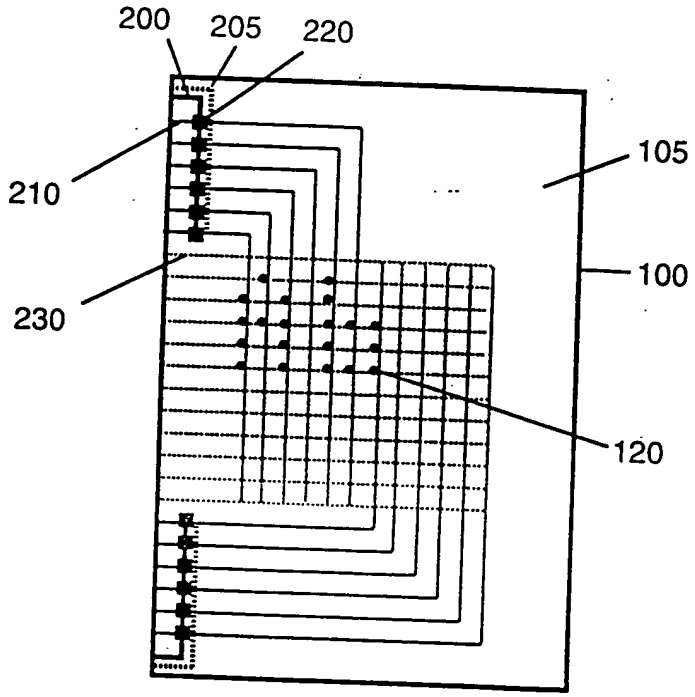


FIG. 3

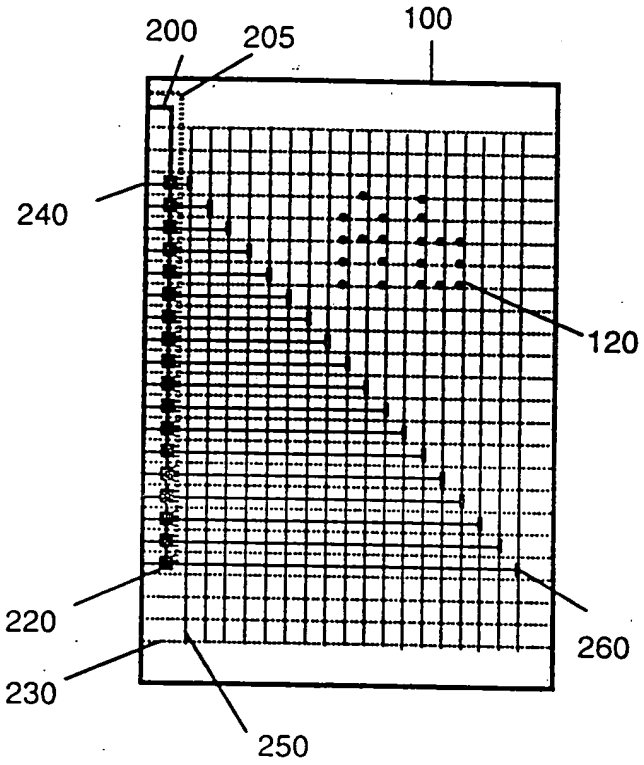
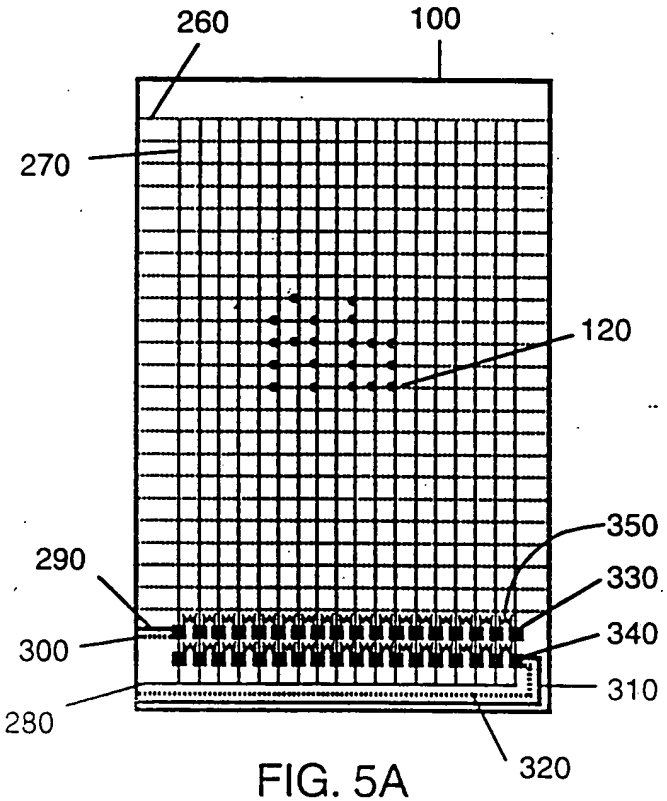


FIG. 4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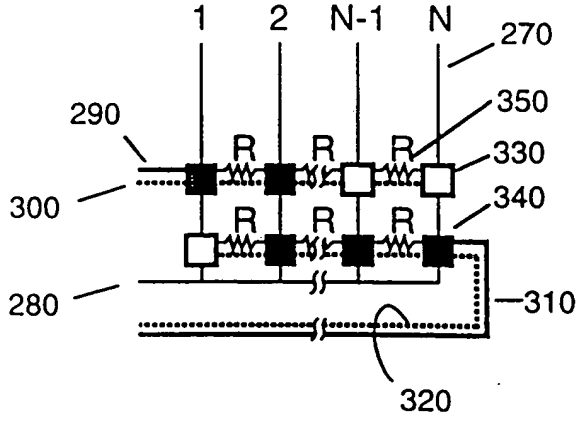
340
300
310
280
320

FIG. 5A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2
N-1
N
270
290
350
R
R
R
330
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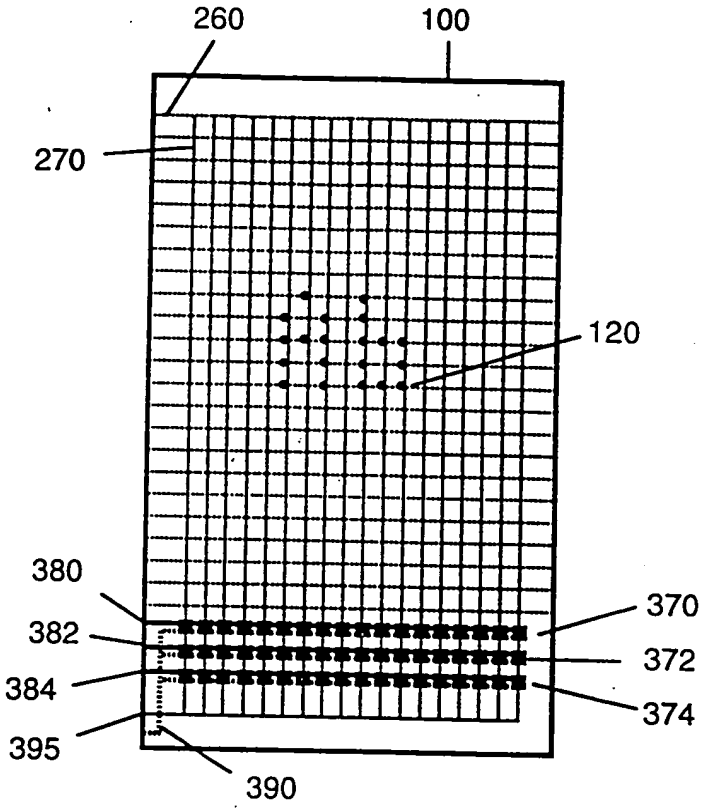
R
R
R
280
310
320

FIG. 5B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100
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120
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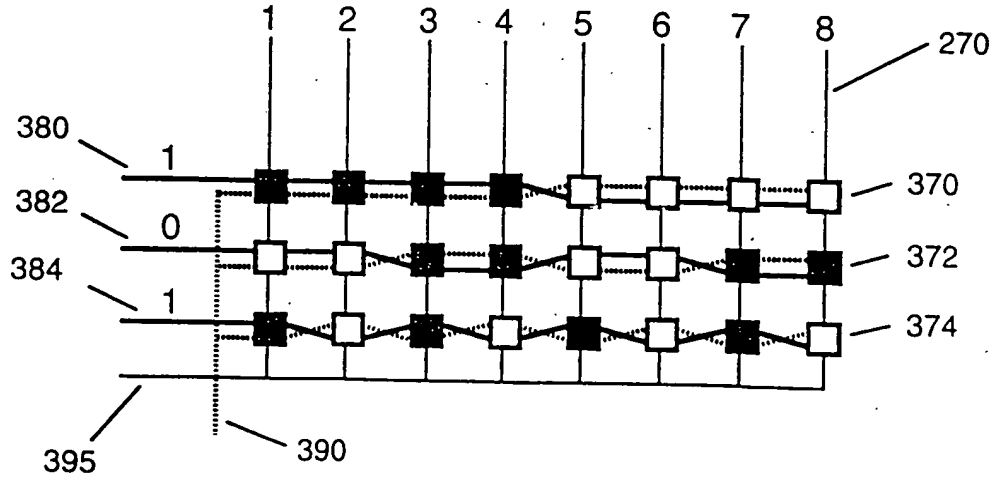
382
384
395
390
370
372
374

FIG. 6A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1
395
390
370
372
374

FIG. 6B

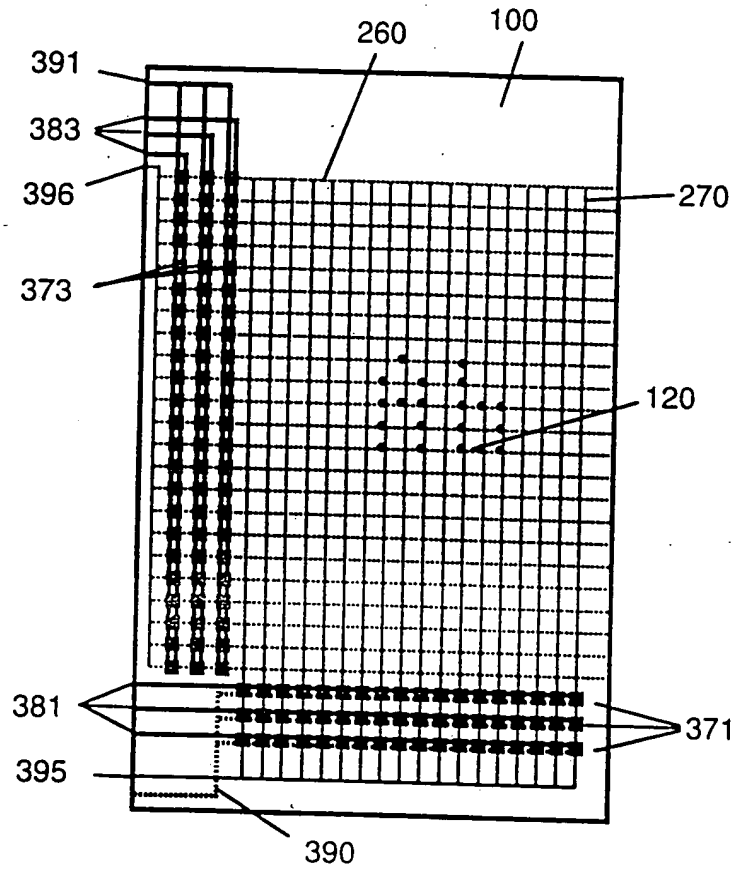


FIG. 6 C

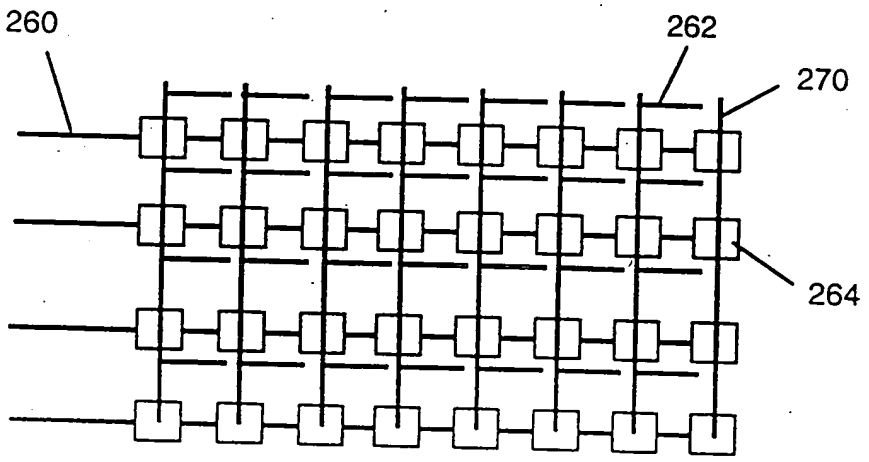


FiG. 6 D

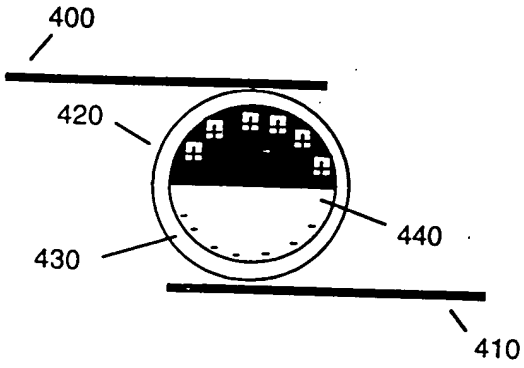


FIG. 7A

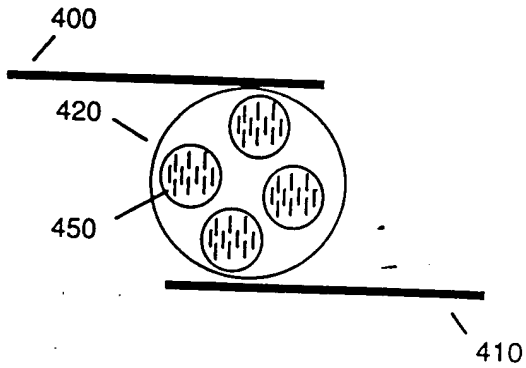


FIG. 7B

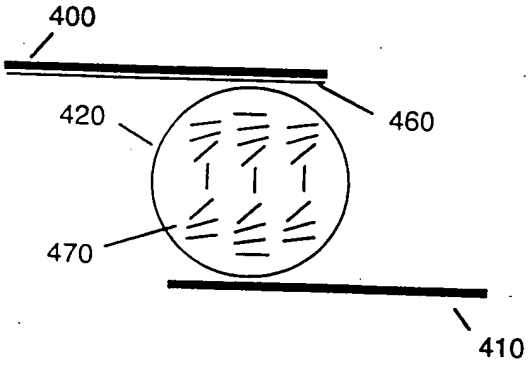


FIG. 7C

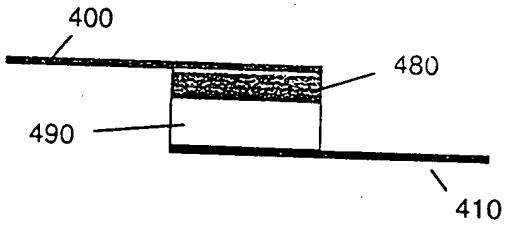


FIG. 7D

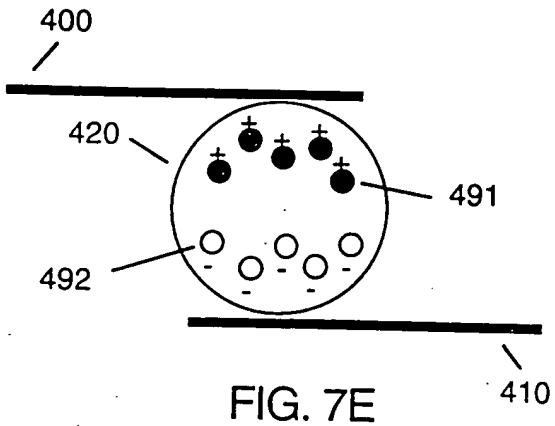


FIG. 7E

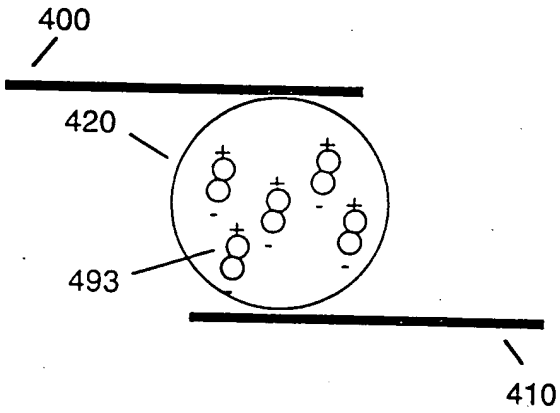


FIG. 7F

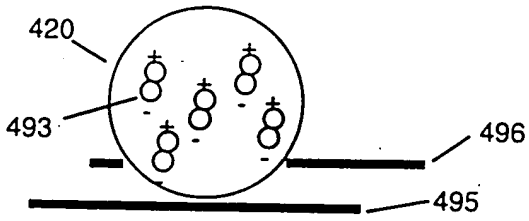


FIG. 7G

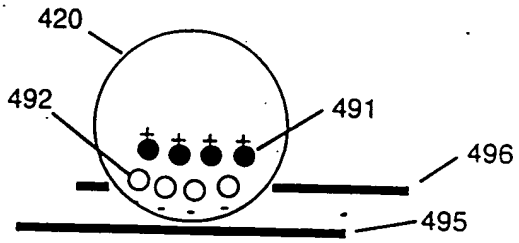


FIG. 7H

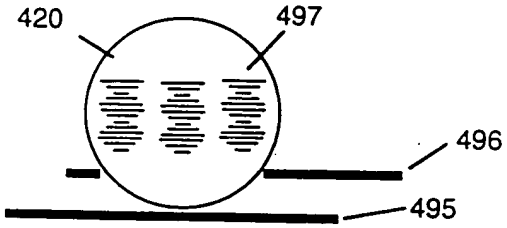


FIG. 7I

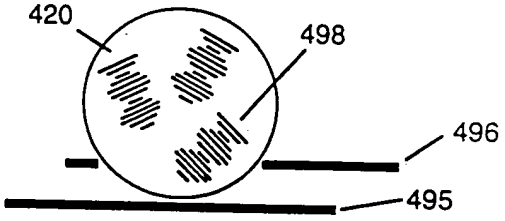


FIG. 7J

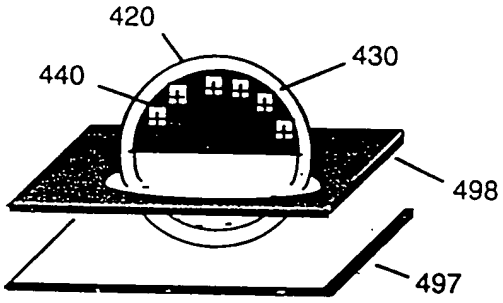


FIG. 7K

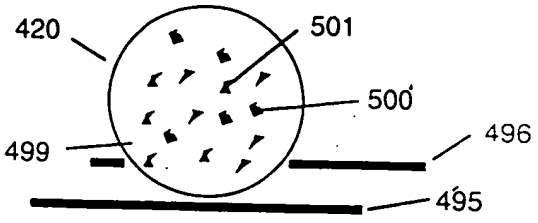


FIG. 7L

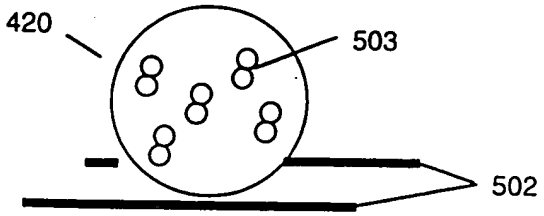


FIG. 7M

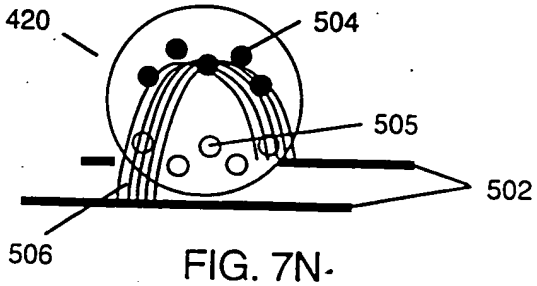


FIG. 7N

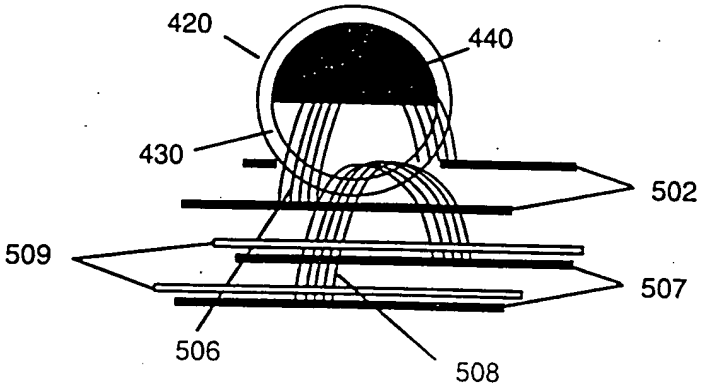


FIG. 7O

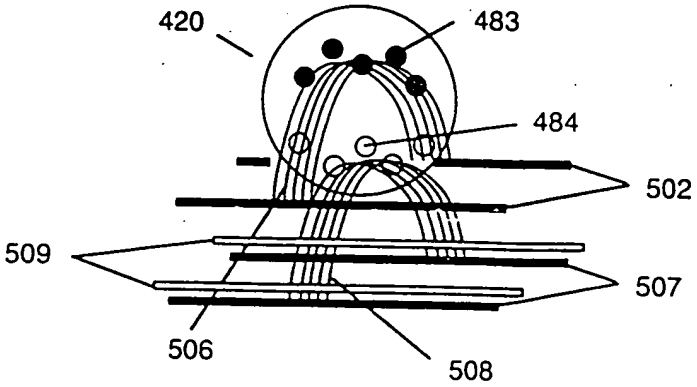


FIG. 7P

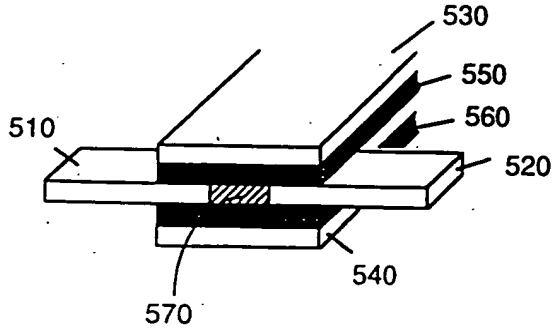


FIG. 8A

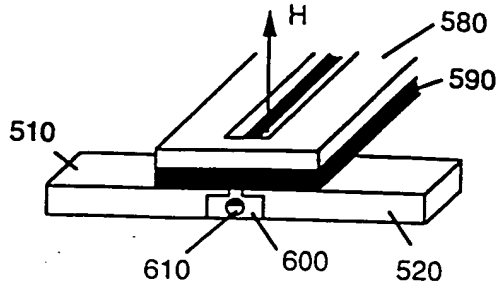


FIG. 8B

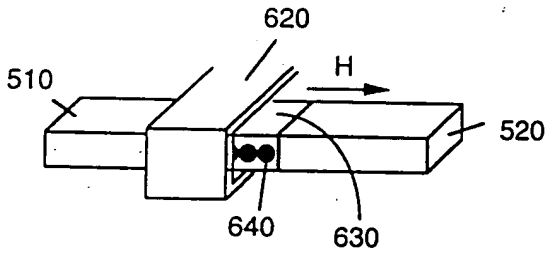


FIG. 8C

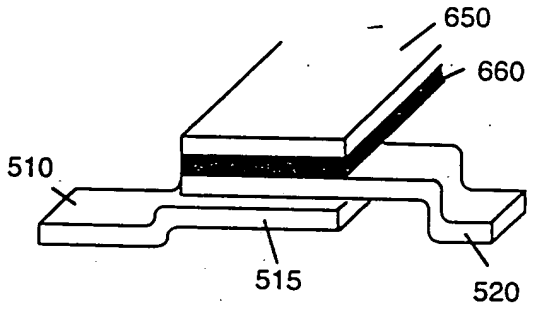


FIG. 8D

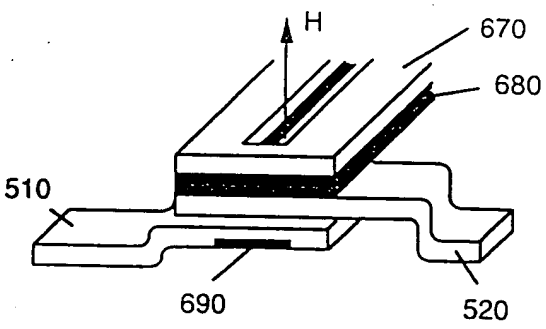


FIG. 8E

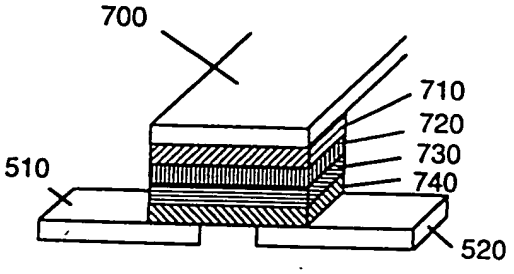


FIG. 9A

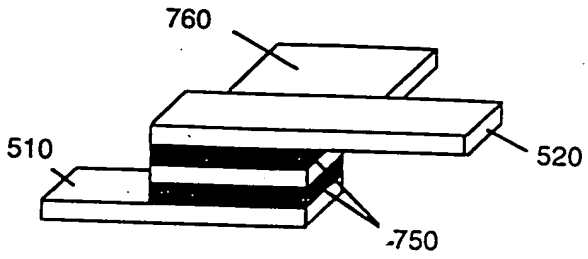


FIG. 9B

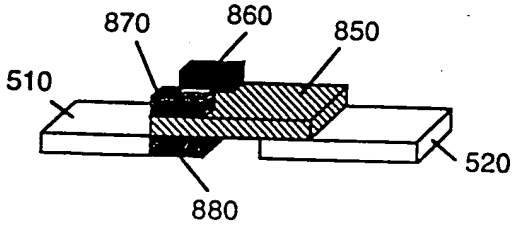


FIG. 9C

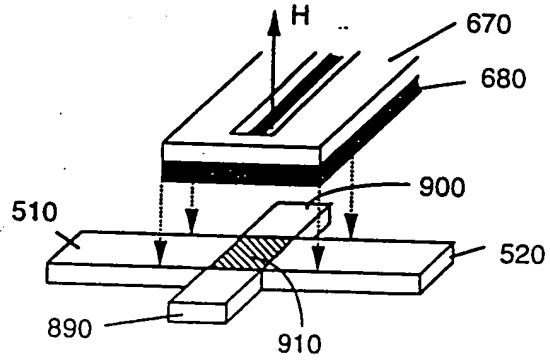


FIG. 9D

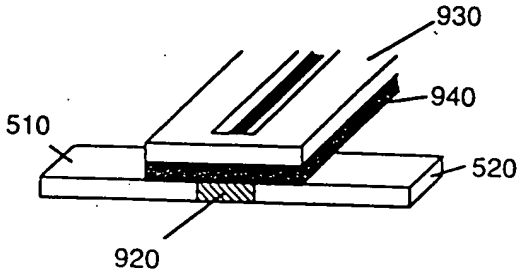


FIG. 9E

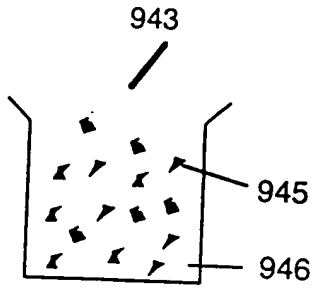


FIG. 9F

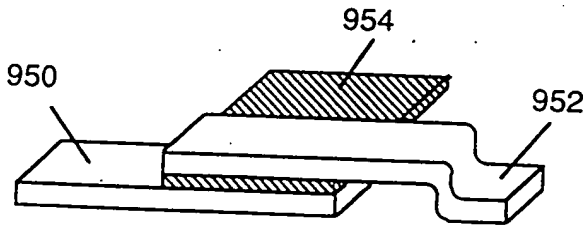


FIG. 9G

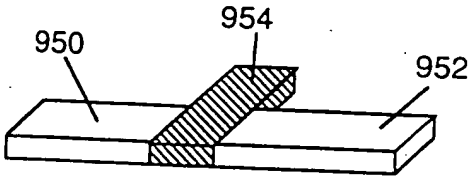


FIG. 9H

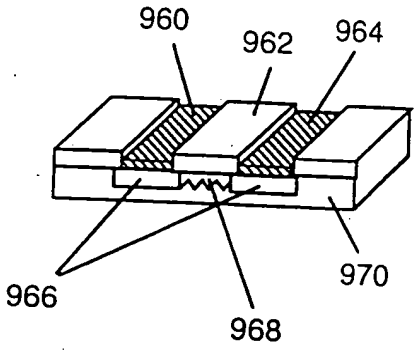


FIG. 9I

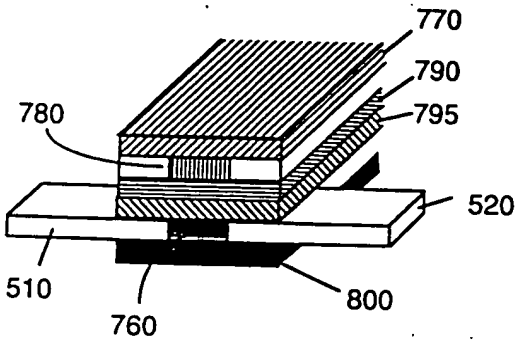


FIG. 10A

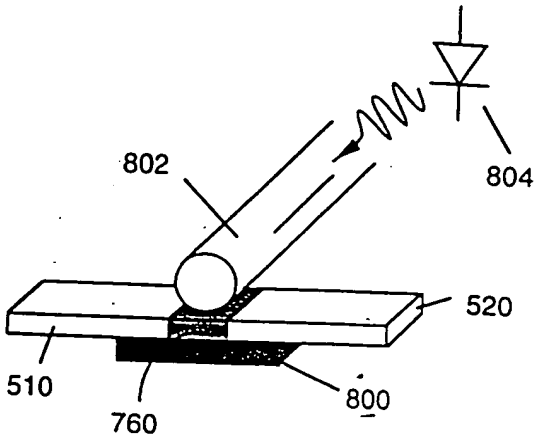


FIG. 10B

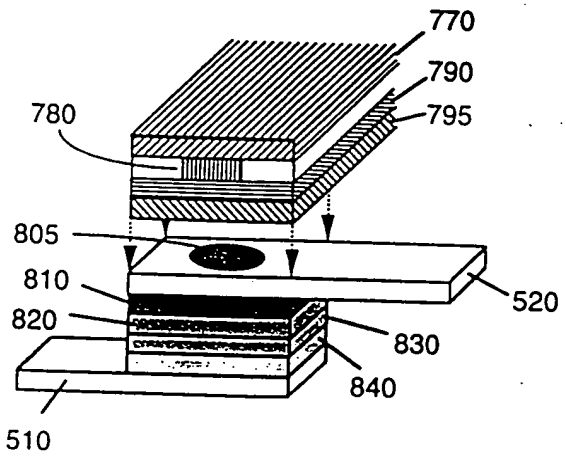


FIG. 10C

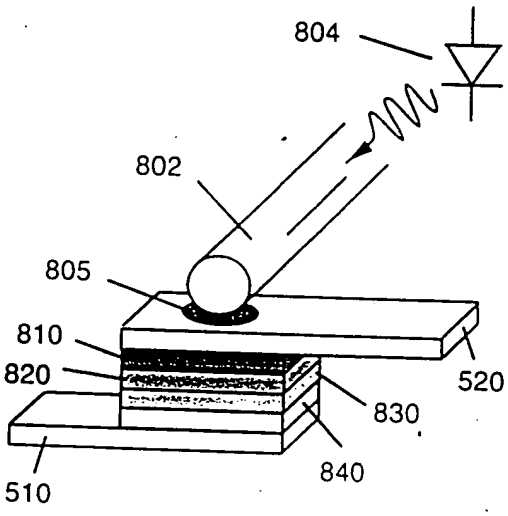


FIG. 10D

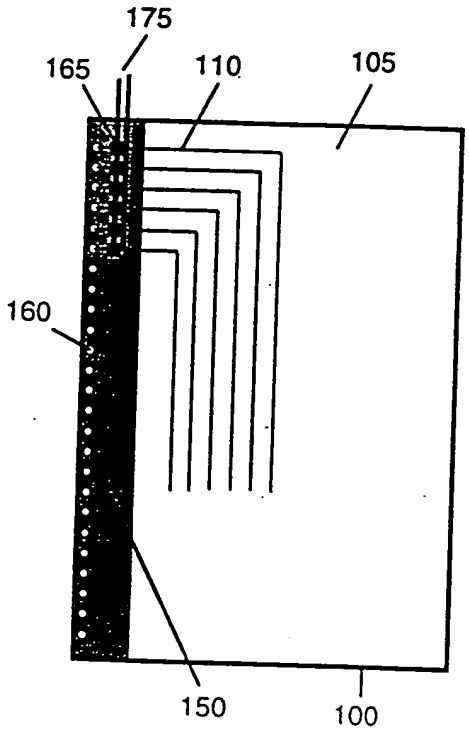


FIG. 11A

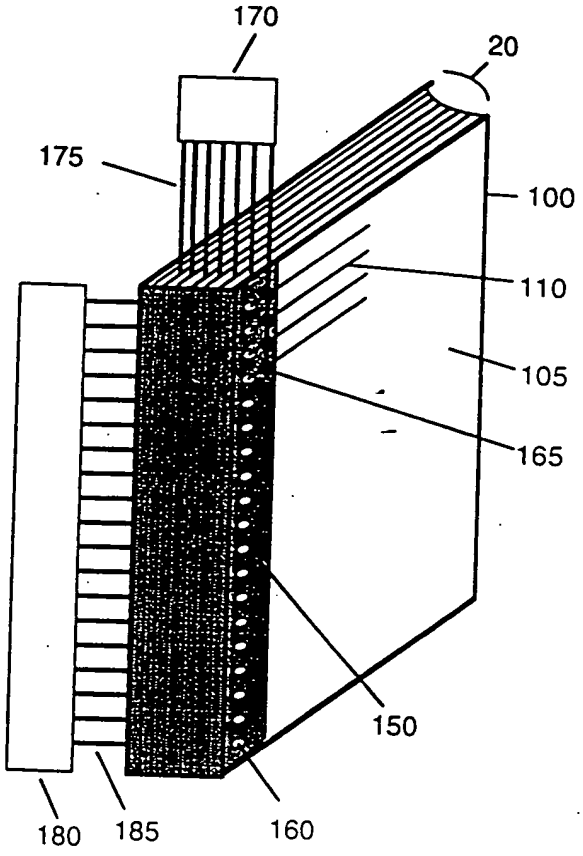
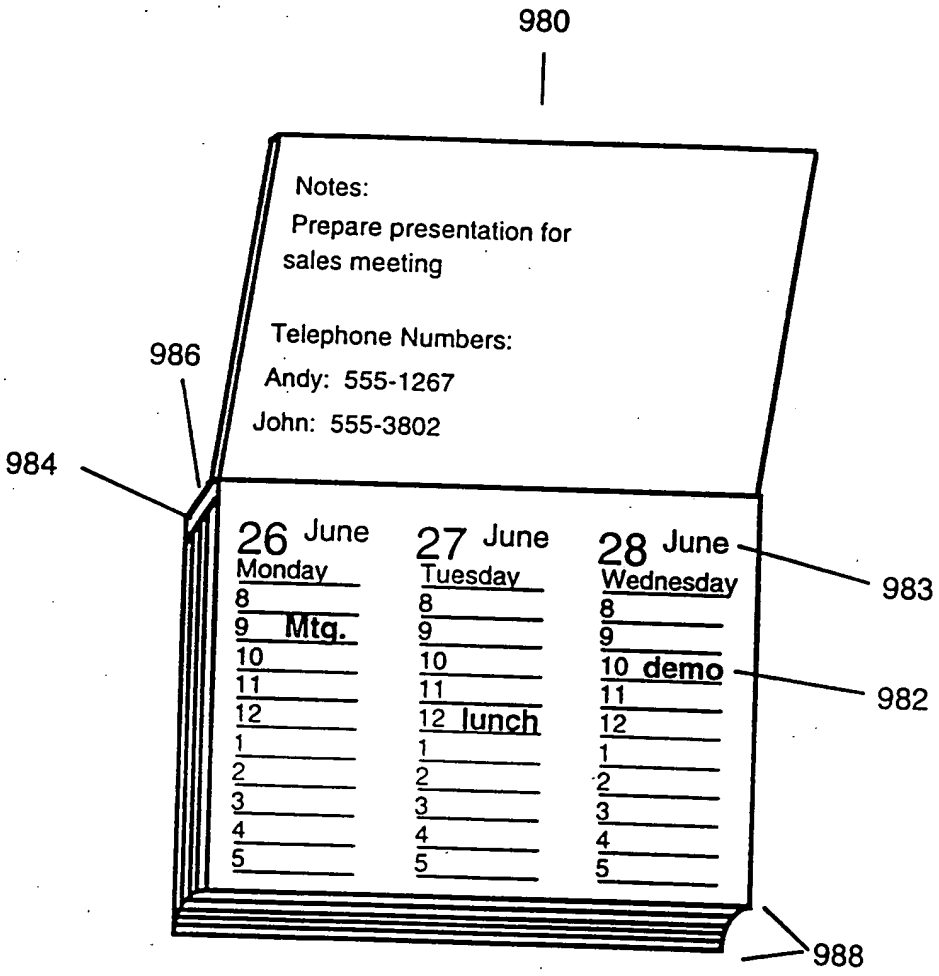


FIG. 11B


980
Notes:
Prepare presentation for sales meeting
Telephone Numbers:
Andy: 555-1267
John: 555-3802
986
984
26 June
Monday
8
9 Mtg.
10
11
12
1
2
3
4
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27 June
Tuesday
8
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12 lunch
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4
5
28 June
Wednesday
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10 demo
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983
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Fig. 12